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65

# ASSESSING THE PERFORMANCE OF DEFORMABLE IMAGE REGISTRATION FOR PELVIS

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**Purpose:** The accumulated delivered dose to mobile organs can be estimated by the use of Deformable Image Registration (DIR). This study assessed the quality of CT-Cone Beam CT (CBCT) DIR based on inclusion of various guiding volumes and/or points for the pelvic region.

**Methods and Materials:** Reference CT and 13 CBCTs from each of 13 prostate patients with intraprostatic fiducial markers (IFM) were retrieved. Prostate, bladder and rectum were delineated on all image datasets. Each CBCT was deformed to the CBCT using DIR by the following: 1) image intensity; 2) 3 IFMs as the guiding points (POIG); 3) bladder and rectum as the guiding volumes (VOIG); and 4) VOIG+POIG. For each DIR, ProstateDIR, BladderDIR, and RectumDIR were generated and compared with the manually delineated volumes on CBCT. Distance between surfaces (DSS) < 2 mm is considered as having good agreement between the volumes.

**Results:** A total of 2028 volumes were generated for analysis. Volumes generated by DIR using image intensity had the lowest agreement (Range of Mean DSS: ProstateDIR = 2 - 6 mm; BladderDIR = 6 - 23 mm; RectumDIR = 2 - 6 mm). The use of POIG decreased the DSS for ProstateDIR but had no impact on either BladderDIR or RectumDIR. Agreement of these volumes increased when VOIG or VOIG+POIG was used (Range of Mean DSS: ProstateDIR = 1 - 2 mm; BladderDIR = 0.9 - 1 mm; RectumDIR = 0.1 - 0.6 mm). Difference between VOIG and VOIG+POIG was not statistically significant ( $p = 0.6$ ).

**Conclusions:** CT-CBCT DIR using VOIG and VOIG+POIG resulted in the smallest difference between volumes. There is no additional benefit of including guiding points when guiding volumes are used to perform DIR. Impact of interobserver variability in contouring guiding volumes on DIR needs to be further investigated.

66

# RETROSPECTIVE ANALYSIS OF INTER-FRACTIONAL WEIGHT LOSS AND SETUP UNCERTAINTIES FOR HEAD AND NECK CANCER PATIENTS

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**Purpose:** The major barrier to widespread adoption of adaptive radiation therapy (ART) is the difficulty of determining which patients would benefit from treatment re-planning. As a preliminary step in designing an ART protocol, our centre recently began to acquire weekly cone beam computed tomography (CBCT) images for head and neck patients. In this work, we analyzed each CBCT for the purpose of suggesting future ART protocols and re-plan trigger points.

**Methods and Materials:** We performed a qualitative retrospective analysis of the CBCT scans of fifteen head and neck cancer patients flagged for possible treatment re-planning between December 2015 and February 2016. All CBCTs were initially flagged by therapists for further review by medical physicists and radiation oncologists if a patient exhibited a body contour change greater than 1.5 cm.

**Results:** Overall, the observed contour changes ranged from 1.5 cm to 3.1 cm with the greatest variability occurring at the clavicle and acromion. The primary goal of weekly CBCT imaging was to track the effects of weight loss during treatment, however in many cases it was difficult to resolve the differences between patient setup uncertainties and anatomical changes. While head and neck immobilization is highly effective at the beginning of treatment, weight loss was seen to exacerbate setup uncertainty in later fractions. For example, contour changes of 2.4 cm and 2.9 cm in the left and right shoulders, and

1.2 cm and 1.6 cm in the left and right cheeks, respectively, were accompanied by an anteroposterior change in chin position of 1.2 cm. PTV contours exceeded the skin by 1.6 cm in this case due to the combined effect of weight loss and setup variability. The limited field of view of CBCT images further contributed to the uncertainty in our analysis; a match of the humeral head or other bony landmark to distinguish weight loss from set up errors in the shoulders and lower neck was not always possible as a result. In addition, we noted that a 1.5 cm change in body contour could correspond to a wide range of dosimetric implications, ranging from relatively minor to potentially significant changes in PTV coverage and healthy tissue sparing. Therefore, to build off of the current 1.5 cm criteria, we propose that the CBCT data be further analyzed to derive dosimetric and anatomical correlations, both within CBCT images and among multiple CBCT data sets. Given the large amount of data available from the current ART weekly CBCT protocol, machine learning and optimization-based methods will likely be the most effective means of optimally designing the re-plan trigger points.

**Conclusions:** It is widely hypothesized that efficient ART methods will serve a vital role in the improvement of treatment quality. We propose that the next development of the ART protocol at our centre be derived from deformable image registration and subsequent machine learning-based analysis of the weekly CBCT scans.

67

# SALVAGE I-125 LDR PROSTATE BRACHYTHERAPY REIMPLANTATION FOR LOCAL FAILURE USING INTRAOPERATIVE PLANNING

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**Purpose:** There are few reports in the literature of salvage reimplantation prostate brachytherapy following local failure. We report on our institutional experience performing salvage reimplantation using LDR intraoperative planning for locally recurrent prostate cancer.

**Methods and Materials:** From 2003-2014, seven out of 823 patients with low- and intermediate-risk localized prostate cancer treated with brachytherapy underwent a salvage reimplantation for biochemical failure and biopsy confirmed recurrence. Restaging included a 3.0 T MRI of the prostate and pelvis prior to reimplantation. Patients were treated with an LDR intraoperative planning technique using I-125 seeds. The prostate was prescribed 144 Gy and the area of recurrence, as detected on biopsy and MRI, was contoured as an area of interest and was the only area covered by the 150% isodose. The base of the seminal vesicles were implanted if felt to be involved. The intraoperative urethral V120 dose was reduced to 0%. Descriptive statistics were used to summarize the results.

**Results:** Intraoperative dosimetry for the first implant showed excellent coverage with a median D90 prostate and V100 of 190 Gy and 99.8% respectively. The median follow up time from initial diagnosis was 10 years (range, 6.1-12.2) and 2.1 years from the time of the second implant. Median time from initial implant to second Implant was 6 years (range 4.2-9.2). Mean PSA at time of reimplantation was 6.0 ng/ml (range, 3.9-13.3). Five of the seven reimplanted patients achieved biochemical control with a PSA nadir of < 0.1 ng/ml. Three patients developed urinary toxicity requiring intervention within 24 months following treatment including two undergoing transurethral resection of prostate and one temporary catheterization for urinary obstruction.

**Conclusions:** A salvage reimplantation for recurrent prostate cancer in select patients with biopsy confirmed local recurrence can achieve biochemical control. Patients are at increased risk of urinary toxicity requiring intervention. A salvage reimplantation at an experienced centre should be considered as a local salvage option following local failure after prostate brachytherapy.